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I, JANENE PEISKER, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2004900788 for a patent by SOLAR HEAT AND POWER PTY. LTD. as filed on 17 February 2004.



WITNESS my hand this  
Twenty-eighth day of February 2005

A handwritten signature in dark ink, appearing to read 'J K 14'.

JANENE PEISKER  
TEAM LEADER EXAMINATION  
SUPPORT AND SALES

**AUSTRALIA**

***Patents Act 1990***

**PROVISIONAL SPECIFICATION**

**MULTI-TUBE SOLAR COLLECTOR STRUCTURE HAVING**  
**A VARIABLE ABSORPTION APERTURE**

The invention is described in the following specification.

## **MULTI-TUBE SOLAR COLLECTOR STRUCTURE HAVING A VARIABLE ABSORPTION APERTURE**

### **5 FIELD OF THE INVENTION**

This invention relates to a solar collector structure that employs a plurality of absorber tubes which are arranged to be illuminated by solar radiation from a reflector field and which provide for a variable absorption aperture. The invention has been developed in the context of  
10 a so-called compact linear Fresnel reflector (CLFR) system and is hereinafter described in relation to such a system. However, it will be understood that the invention may have broader application.

### **BACKGROUND OF THE INVENTION**

15 Prior art solar collector structures of the type with which the present invention might be compared may be categorised generally as falling within two groups; a first group that employs effectively a single absorber tube that extends along the focal line of a non-inverted trough-type reflector and a second group that employs a single absorber  
20 tube that extends along the focal line of an inverted trough-type reflector. Collector systems of the first group suffer the disadvantages that the absorber tube collects incident solar energy from one only reflector element and requires complex mounting and fluid coupling arrangements. Collector systems of the second group largely avoid the  
25 disadvantages of the first group but suffer the disadvantage of losses occasioned by the need for multiple reflections, firstly from ground-mounted reflectors and then from the inverted trough reflectors. Moreover, to the extent that the collector systems of both the first and the second groups employ a single absorber tube, those collector  
30 systems are not capable of providing a variable absorption aperture.

### **SUMMARY OF THE INVENTION**

The present invention provides a collector structure that is arranged to be located at a level above a field of reflectors and to receive solar radiation reflected from reflectors within the field. The collector structure comprises an inverted trough and, located within the trough, a plurality of longitudinally extending absorber tubes that, in use, are arranged to carry a heat exchange fluid. The absorber tubes are supported side-by-side within the trough and means are provided for selectively controlling the channelling of the heat exchange fluid into and through the absorber tubes whereby the absorption aperture of the collector structure is, in use, effectively varied.

In a preferred embodiment of the invention the aperture of the trough (as distinct from the absorption aperture) is large relative to the diameter of each absorber tube. That is, the ratio of the absorber tube diameter to the trough aperture dimension may, for example, be in the range of 0.01:1.00 to 0.10:1.00 and typically be of the order of 0.03:1.00. With this arrangement the plurality of tubes will, in the limit, effectively simulate a flat plate absorber.

A plurality of the collector structures as above defined may be connected together co-linearly to form a row of the structures and, in such case, each of the absorber tubes will extend along the full row, either as a single length of tubing or as conjoined lengths of tubing.

### **OPTIONAL FEATURES OF THE INVENTION**

The absorber tubes may be constituted by metal tubes and each tube may, if required, be coated over at least a portion of its surface with a solar absorptive coating. In an alternative arrangement, each absorber tube may comprise a glass or metal tube that is itself coated with a solar selective surface coating and that is located within a surrounding evacuated glass tube.

The inverted trough may (but need not necessarily) be located below a longitudinally extending roof and, in such case, an insulating material may be located between the trough and the roof.

- 5 The invention will be more fully understood from the following description of an exemplary embodiment of the solar collector structure. The description is provided by way of example with reference to the accompanying drawings.

10 **BRIEF DESCRIPTION OF THE DRAWINGS**

In the drawings-

Figure 1 shows a largely diagrammatic representation of a CLFR system that comprises a field of ground mounted reflectors that are arrayed in rows and collector systems that are constituted by rows of aligned

- 15 collector structures;

Figure 2 illustrates schematically the reflection of solar radiation from four reflectors to two collector systems within the CLFR system;

Figure 3 shows an aerial view of a portion of a field of reflectors and a single collector structure positioned adjacent one edge of the field;

- 20 Figure 4 shows a perspective view (from above) of a terminal end of a collector structure of the type shown in Figure 3;

Figure 5 shows a sectional end view of the collector structure of Figure 4;

- 25 Figure 6 shows a portion of the collector structure which is encircled by circle A in Figure 5;

Figure 7 shows a portion of the collector structure which is encircled by circle B in Figure 5;

Figure 8 shows diagrammatically a fluid flow control arrangement for a collector system that comprises a row of four interconnected collector structures; and

- 30 Figures 9A, 9B and 9C show alternative fluid channelling arrangements that provide for different effective absorption apertures.

### **DETAILED DESCRIPTION OF THE INVENTION**

As shown in Figures 1 to 3, the CLFR system comprises a field of ground mounted reflectors 10 that are arrayed in rows 11 and further comprises parallel collector systems 12, each of which is constituted by aligned collector structures 13. A complete CLFR system might occupy a ground area within the range  $5 \times 10^1 \text{ m}^2$  to  $25 \times 10^6 \text{ m}^2$  and the system as illustrated in Figure 1 may be considered as a portion only of a larger CLFR system.

10 The reflectors 10 may be of the type described in co-pending Provisional Patent Applications numbered 2003903335, 2003903336 and 2003903341, filed 01 July 2003 by the present Applicant, and the disclosures of these Patent Applications are incorporated herein by reference.

15 The reflectors are driven collectively, regionally, as rows or individually to track movement of the sun (relative to the earth) and they are orientated to reflect incident radiation to respective ones of the collector systems 12, as shown schematically in Figure 2. Also, some or all of the reflectors may be driven so as to reorientate, when required, to change the direction of reflected radiation from one collector system to another.

In the system as illustrated in Figure 1 and as would typically be the case, each collector system 12 receives reflected radiation from twelve rows of reflectors 10. Thus, each collector system 12 receives reflected radiation from six rows at one side of the collector system and from six rows at the other side, although (as indicated in Figure 2) the reflecting rows need not necessarily be immediately adjacent the receiving collector system.

30 Each row 11 of reflectors 10 and, hence, each collector system 12 might typically have an overall length of 300 metres, and the parallel collector

systems 12 might typically be spaced apart by 30 to 35 metres. The collector systems 12 are supported at a height of approximately 11 metres by stanchions 14 which are stayed by ground-anchored guy wires 15.

5

As indicated previously, each of the collector system 12 comprises a plurality of collector structures 13 that are connected together co-linearly to form a row of the structures. Each of the collector structures has a length of the order of 12 metres and an overall width of  
10 the order of 1.4 metres.

Each collector structure 13 comprises an inverted trough 16 which is formed from stainless steel sheeting and which, as best seen in Figure 5, has a longitudinally extending channel portion 17 and flared side  
15 walls 18 that, at their margins, define an aperture of the inverted trough. The trough 16 is supported and provided with structural integrity by side rails 19 and transverse end members 20, and the trough is surmounted by a corrugated steel roof 21 that is carried by  
arched structural members 22.

20

The void between the trough 16 and the roof 21 is filled with a thermal insulating material 23, typically a glass wool material, and desirably with an insulating material that is clad with a reflective metal layer. Clearly, the function of the insulating material is to inhibit upward  
25 conduction and radiation of heat from within the trough.

A longitudinally extending window 24 is provided to interconnect the side walls 18 of the trough. The window is formed from a sheet of material that is substantially transparent to solar radiation and it  
30 functions to define a closed (heat retaining) longitudinally extending cavity 25 within the trough.



The window 24 may be formed from glass but it desirably is formed from a transparent heat resistant plastics material having a thickness of the order of  $60 \times 10^{-6}$  m. As shown in Figure 7, side margins of the window may be welded to a wire or other heat resistant rope core 26 and the window may be held in position by slideably locating the cored side margins in fluted side connectors 27.

Figure 4 shows a collector structure 13 that is intended to be located at a terminal end of a row 12 of the collector structures, and it is provided with an end wall 28 to which is mounted a motor driven blower 29. The blower is provided in use to maintain a positive air pressure within the cavity 25 (relative to the ambient atmospheric pressure) and so to inflate the window in a direction away from absorber tubes 30 within the inverted trough 16.

In the collector structure as illustrated, sixteen longitudinally extending stainless steel absorber tubes 30 are provided for carrying heat exchange fluid (typically water or, following heat absorption, water-steam or steam). However, the actual number of absorber tubes may be varied to suit specific system requirements. Desirably, each absorber tube has a diameter that is small relative to the aperture of the trough.

The actual ratio of the absorber tube diameter to the trough aperture dimension may be varied to meet system requirements but, in order to indicate an order of magnitude of the ratio, it might typically be within the range 0.01:1.00 to 0.10:1.00. Each absorber tube 30 might have an outside diameter of 33 mm. and, with an aperture dimension of 1100mm, the ratio of the absorber tube diameter to the aperture dimension will be 0.03:1.00.

As indicated previously, with the above described arrangement the plurality of absorber tubes 30 will, in the limit, effectively simulate a flat plate absorber, as compared with a single-tube collector in a concentrating trough. This provides for increased operating efficiency, in terms of a reduced level of heat emission from the upper, non-illuminated circumferential portion of the absorber tubes. Moreover, by positioning the absorber tubes in the inverted trough in the manner described, the underside portion only of each of the absorber tubes is illuminated with incident radiation, this providing for efficient heat absorption in absorber tubes that carry steam above water.

The absorber tubes 30 are freely supported by a series of parallel support tubes 31 which extend between side walls 32 of the channel portion 17 of the inverted trough, and the support tubes 31 are carried by spigots 33. This arrangement accommodates expansion of the absorber tubes and relative expansion of the individual tubes. Disk-shaped spacers 34 are carried by the support tubes 31 and serve to maintain the absorber tubes 30 in spaced relationship.

Each of the absorber tubes 30 is coated, along its length and around a (lower) portion of its circumference that is exposed to incident solar radiation, with a solar absorptive coating. The coating may comprise a solar selective surface coating that remains stable under high temperature conditions in ambient air or it may comprise a high-temperature resistant black paint.

Figure 8 of the drawings shows diagrammatically a flow control arrangement for controlling flow of heat exchange fluid into and through four in-line collector structures 13. As illustrated, each of the fluid lines 30A, B, C and D is representative of four of the absorber tubes 30 as shown in Figure 5.

Under the controlled condition illustrated in Figure 8, in-flowing heat exchange fluid is first directed along forward line 30A, along return line 30B, along forward line 30C and finally along and from return line 30D. This results in fluid at a lower temperature being directed through  
5 tubes that are located along the margins of the inverted trough and a consequential emission reduction when radiation is concentrated over the central region of the inverted trough. An electrically actuated control device 35 is provided to enable selective control over the channelling of the heat exchange fluid.

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Alternative fluid flow conditions may be established to meet load demands and/or prevailing ambient conditions, and provision may effectively be made for a variable aperture collector structure by closing selected ones of the absorber tubes. Thus, variation of the effective  
15 absorption aperture of the collector structure may be achieved by controlling the channelling of the heat exchange fluid in the manners shown in Figures 9A to 9C.

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Variations and modifications may be made in the invention as above described and defined in the following statements of claim.

25

1. A collector structure that is arranged to be located at a level above a field of reflectors and to receive solar radiation reflected from reflectors within the field, the collector structure comprising an inverted trough and, located within the trough, a plurality of longitudinally extending  
25 absorber tubes that, in use, are arranged to carry a heat exchange fluid, the absorber tubes being supported side-by-side within the trough and means being provided for selectively controlling the channelling of the heat exchange fluid into and through the absorber tubes whereby the  
30 absorption aperture of the collector structure is, in use, effectively varied.

2. The collector structure as defined in claim 1 wherein the aperture of the trough (as distinct from the absorption aperture) is large relative to the diameter of each absorber tube.

- 5 3. The collector structure as defined in claim 2 wherein the ratio of the absorber tube diameter to the trough aperture dimension is in the range of 0.01:1.00 to 0.10:1.00.

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Solar Heat and Power Pty Ltd  
13 February 2004

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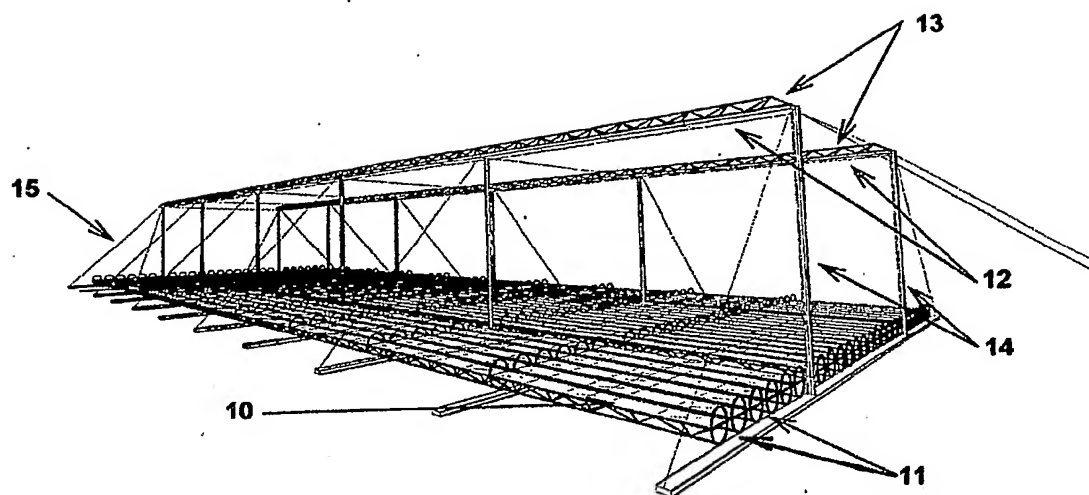


FIG 1.

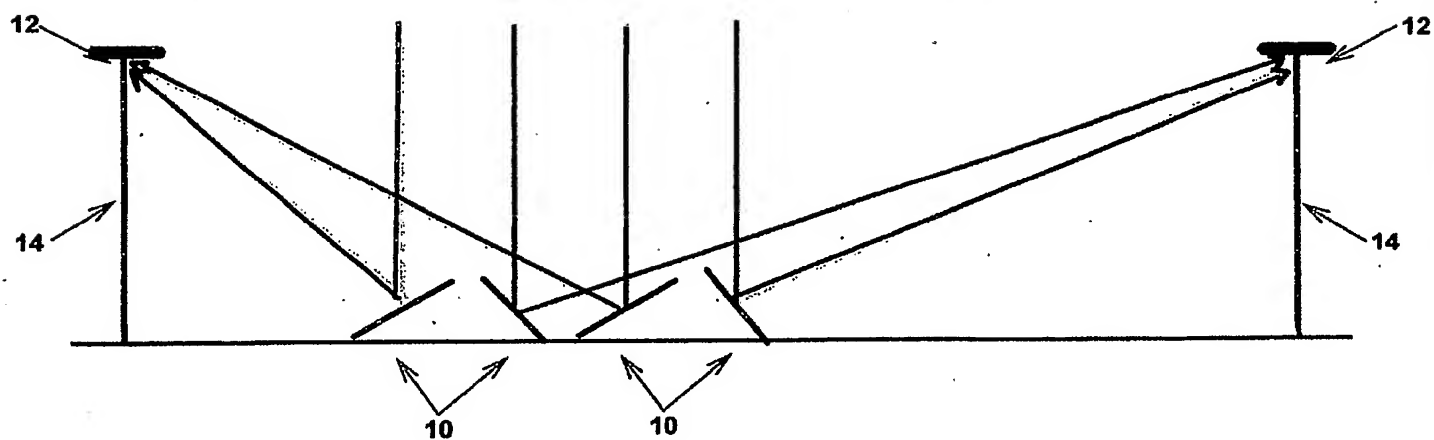


FIG 2.

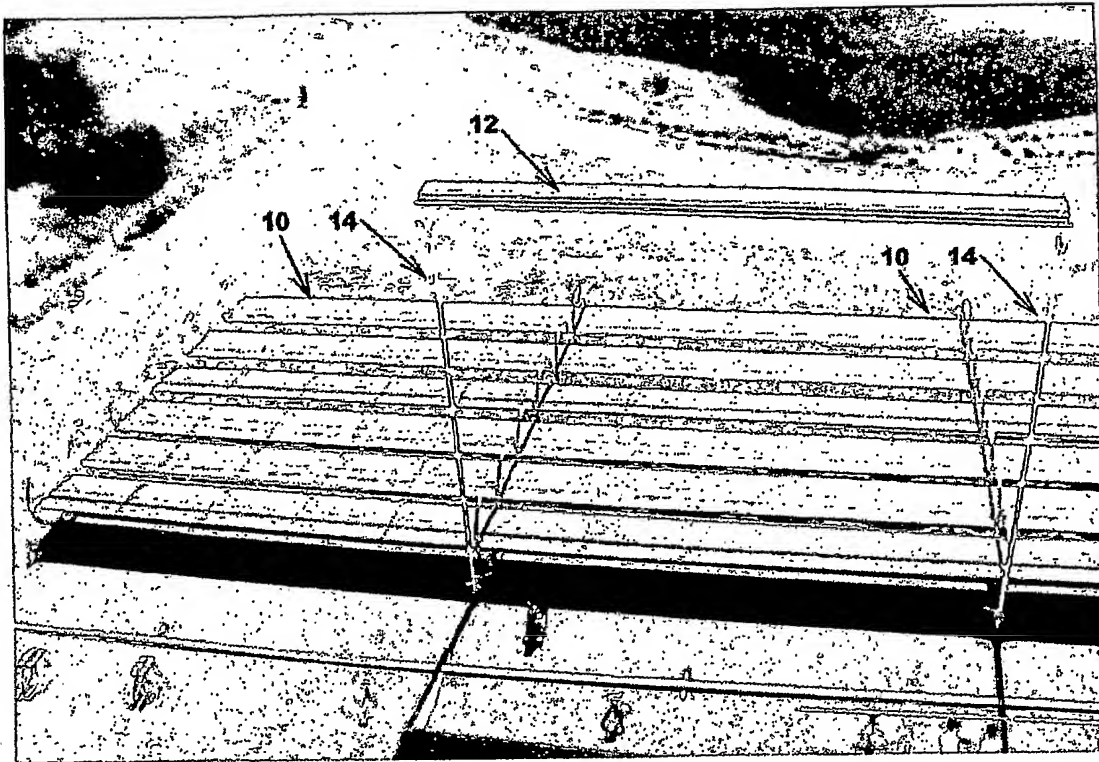


FIG 3.

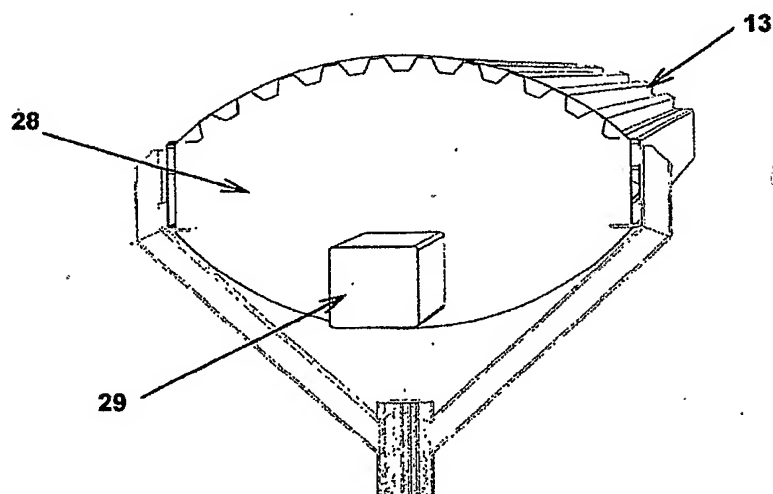


FIG 4.

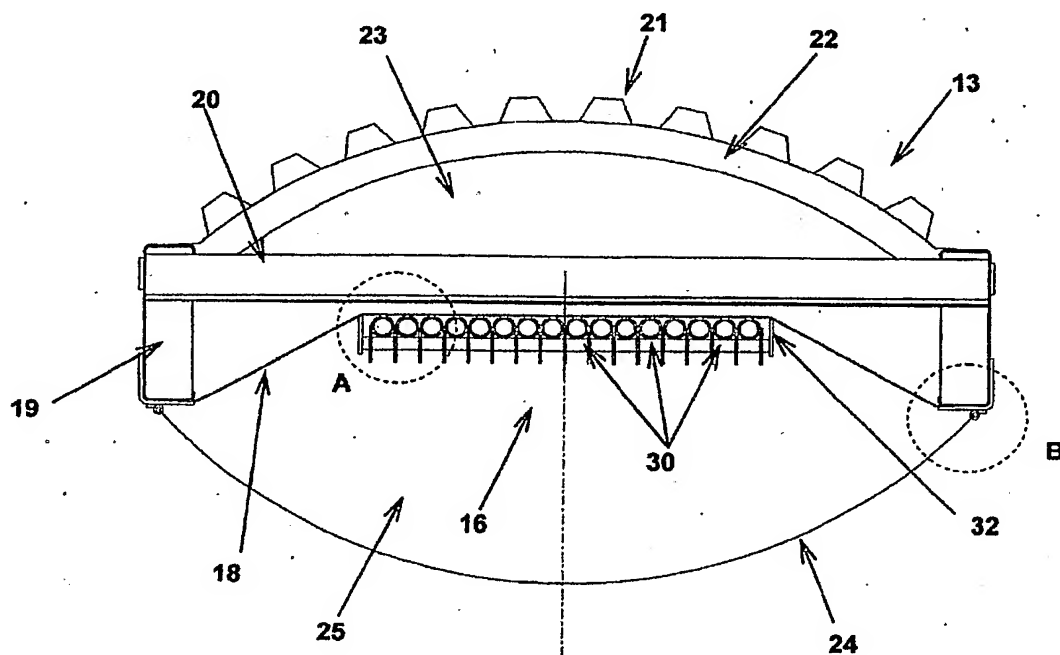


FIG 5.

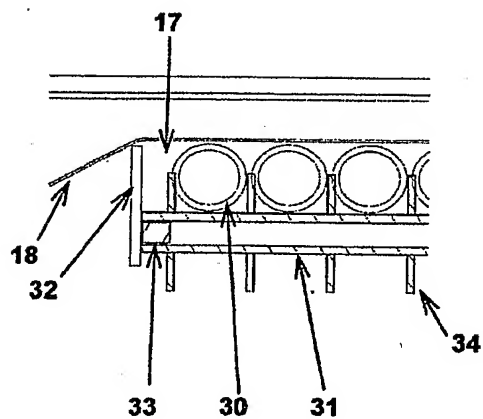


FIG 6.

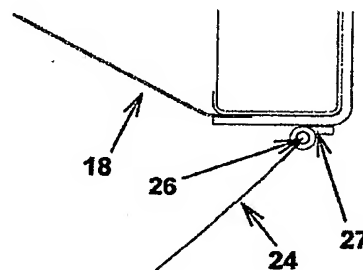
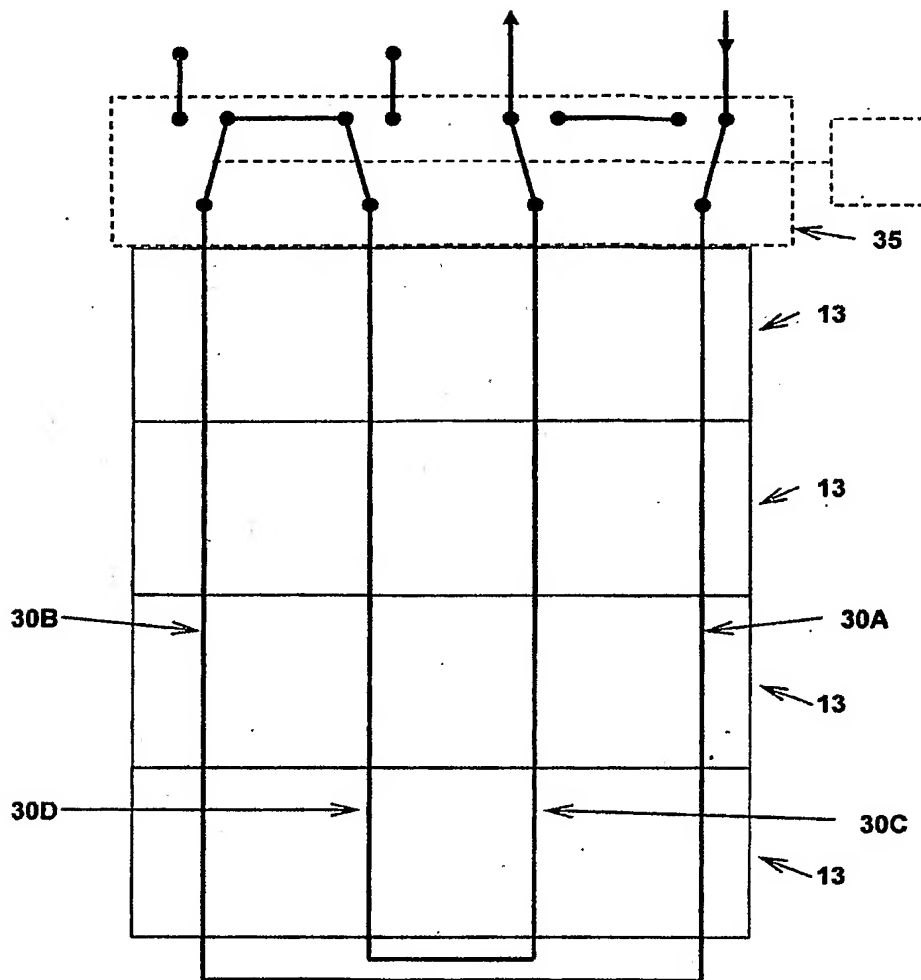


FIG 7.



**FIG. 8**



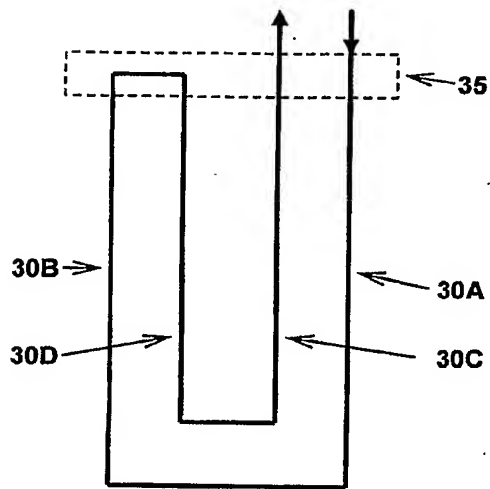


FIG. 9A

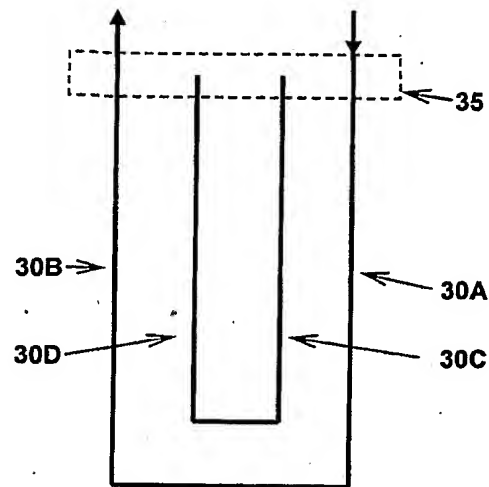


FIG. 9C

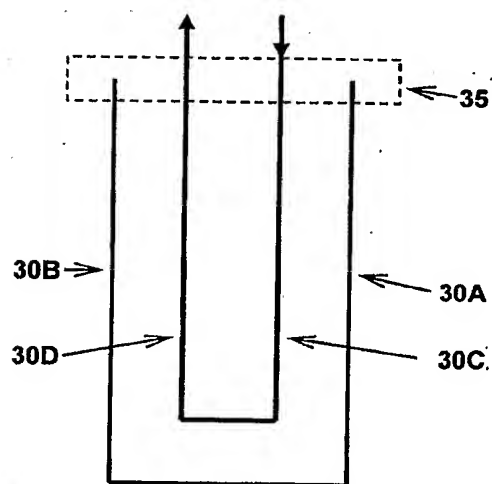


FIG. 9B